OPTICAL CHARACTERIZATION OF MARINE MICROORGANISMS AND OTHER BIOGENIC PARTICLES

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LONG-TERM GOAL

The long-term goal of this research is to develop the base of knowledge necessary to:
(i) understand the magnitudes and variability of the optical properties in the upper ocean;
(ii) predict spectral absorption and scattering by seawater as well as underwater light fields and water-leaving radiant fluxes, given the types and concentration of suspended particles.

SCIENTIFIC OBJECTIVES

My specific objective during the past year was to expand a database of single-particle optical properties for various types of marine microorganisms.

APPROACH

The development of the database of single-particle optical properties is based upon several recent studies, which combine laboratory measurements of various microbial cultures with modeling of particle optics. The specific studies of microbial cultures, which we used in the expansion of the database during the past year, were conducted in the laboratory in Villefranche-sur-Mer (France) in the years 1988-1993. The expanded database includes the fundamental single-particle optical properties that are required as input to radiative transfer models: the absorption and scattering cross-sections and scattering phase function for each microbial species. In addition, the database includes the absorption and scattering efficiency factors, attenuation cross-sections and efficiency factors, single-scattering albedo, backscattering ratio and backscattering cross-section. For phytoplankton species, chlorophyll-specific optical coefficients are available; and for some species carbon-specific coefficients are also available. The optical quantities are determined in the spectral region from 400 to 750 nm at 1-nm intervals. The scattering phase function is determined at 1-degree intervals in the scattering angle (for angles > 5^{o}) and at 0.1-degree intervals for smaller scattering angles. The size distribution and refractive index of particles are also determined. The optical properties in the present database represent certain averages for each microbial species. This database of average properties thus reflects the interspecies variability among various types of microorganisms. The intraspecies variability, associated with

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the fact that the optical properties of any microbial species may vary in response to changes in ambient growth conditions, is unaccounted for in the present database.

WORK COMPLETED

The first version of the database included representatives from five classes of microbial particles: viruses, heterotrophic bacteria, cyanobacteria (*Synechococcus* clone WH 8103), small nanoplanktonic diatoms (*Thalassiosira pseudonana*, Bacillariophyceae), and nanoplanktonic chlorophytes (*Dunaliella tertiolecta,* Chlorophyceae). The paper describing this database has been published (Stramski and Mobley, 1997), and the significance of the database for advancing the science of ocean optics has been discussed in the contribution to the IGARSS'97 Symposium (Stramski, 1997). The use of the database in radiative transfer modeling under separate ONR-sponsored project has been described in Mobley and Stramski (1997).

Additions to the database which were completed during the past year include the optical properties for 15 phytoplankton species covering a broad range of cell size from 0.5 to about 30 micrometers. These species are: *Prochlorococcus* (3 different strains), *Synechococcus* (4 different strains), *Synechocystis* (Cyanophyceae), *Anacystis marina* (Cyanophyceae), *Pavlova pinguis* (Haptophyceae), *Pavlova lutheri* (Haptophyceae), *Isochrysis galbana* (Haptophyceae), *Emiliania huxleyi* (Haptophyceae), *Porphyridium cruentum* (Rhodophyceae), *Chroomonas fragarioides* (Cryptophyceae), *Prymnesium parvum* (Haptophyceae), *Dunaliella bioculata* (Chlorophyceae), *Chaetoceros curvisetum* (Bacillariophyceae), *Hymenomonas elongata* (Haptophyceae), *Prorocentrum micans* (Dinophyceae).

In addition to the database work, fours papers and technical reports were published during the past year, which include my contributions in association with this ONR project.

IMPACT/APPLICATIONS

The major significance and applicability of the database stems from the fact that all basic information on single-particle optical properties required to carry out radiative transfer calculations is included. In another ONR-sponsored project (see the annual report by Mobley and Stramski) we show how powerful a combination of such a database and radiative transfer modeling is in the study of oceanic optics (Mobley and Stramski, 1997). In that project, we take advantage of the fact that, for the first time, we have information available on single-particle optical properties of various microorganisms with hyperspectral resolution and a numerical radiative transfer model that is computationally efficient enough to permit extensive analysis of the effects of various particle types on light field characteristics within and leaving a water body. The role of the database of single-particle optical properties in this approach is essential because it allows us to advance the study of oceanic optics with unprecedented detail beyond the traditional, overly simplified parameterization of sea water composition in terms of chlorophyll concentration alone.

TRANSITIONS

Parts of the database have been made available to academic researchers involved in ocean optics and radiative transfer modeling (A. Morel and A. Bricaud in France, R. Stavn, A. Petrenko, and Robert Leathers, the graduate student with N.J. McCormick). We anticipate that the database will generate a significant interest among scientists involved in ocean optics research, remote sensing of ocean color, and development of optical models for the use by the Navy.

RELATED PROJECTS

The database of single-particle optical properties is used in another ONR-sponsored project which is aimed at studying influences of various types of particles on oceanic optics through the application of radiative transfer modeling (see report by Mobley and Stramski). In addition, the database has been used in the NASA-sponsored project on the analysis of bio-optical components from ocean color imagery (Kiefer and Stramski).

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